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Performance of Goddard earth observing system GCM column radiation models under heterogeneous cloud conditions

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Abstract

We test the performance of the shortwave (SW) and longwave (LW) Column Radiation Models (CORAMs) of Chou and collaborators with heterogeneous cloud fields from a single-day global dataset produced by NCAR's Community Atmospheric Model (CAM) with a 2-D Cloud Resolving Model (CRM) installed in each column. The original SW version of the CORAM performs quite well compared to reference Independent Column Approximation (ICA) calculations for boundary fluxes (global error ~ 4 W m^{-2} for reflected flux), largely due to the success of a combined overlap and cloud scaling parameterization scheme. The absolute magnitude of errors relative to ICA are even smaller (global error ~ 2 W m^{-2} for outgoing flux) for the LW CORAM which applies similar overlap. The vertical distribution of heating and cooling within the atmosphere is also simulated quite well with daily averaged zonal errors always less than 0.3 K/day for SW and 0.6 K/day for LW heating (cooling) rates. The SW CORAM's performance improves by introducing a scheme that accounts for cloud inhomogeneity based on the Gamma Weighted Two Stream Approximation (GWTSA).

These results suggest that previous studies demonstrating the inaccuracy of plane-parallel models may have unfairly focused on worst case scenarios, and that current radiative transfer algorithms in General Circulation Models (GCMs) may be more capable than previously thought in estimating realistic spatial and temporal averages of radiative fluxes, as long as they are provided with correct mean cloud profiles. However, even if the errors of our particular CORAMs are small,

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